Invited Lecture

POLARIZATION IN SPECTRAL LINES FORMED BY SCATTERING: FROM THE LINE CENTER TO THE FAR WINGS

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We will present a new theory able to model both resonant scattering and Rayleigh or Raman scattering in a unified formalism. The resonant scattering results from photon absorption by an atom, followed by emission. The upper line level is reached and populated, and the reemission is frequency incoherent with respect to the absorption, but they remain both in the line core. Atom and radiation are fully coupled, the state of the one being able to provide the state of the other one. Alternatively, in the Rayleigh or Raman scattering, the light rebounds on the atom, coherently in frequency. The upper level is not populated, and a virtual level is reached instead. Atom and radiation are then decoupled. This scattering is the one of the line far wings. This was already described in a quantum formalism by Omont, Smith and Cooper (1972, 1973), but for a 2-level atom and in terms of scattering amplitudes. We will present a new formulation able of a multilevel atom, i.e. by including resolution of the statistical equilibrium equations of the atomic density matrix elements. The radiative transfer equation coefficients are also derived. As the density matrix elements are developed on the basis of Zeeman substates, including the off-diagonal elements usually called coherences, the formalism is able of polarization and Hanle effect. Numerical application to the formation of polarization of the sodium D lines observed near the solar limb will be presented. This application includes resolution of the statistical equilibrium equations and integration of the radiative transfer equation.